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WATSAN – DOLAKHA DISTRICT VULNERABILITY ASSESSMENT REPORT

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1 DISTRICT ASSETS/SYSTEM PRIORITIES

1.1 Dolakha District WATSAN Infrastructure

Dolakha district contains 55 water supply projects completed by different agencies. The majority of the projects have been completed by the District Water Supply Office (DWSO), the lead government department for the sector. Dolakha is a hilly district and has an excellent topography that helped the majority of the water supply projects to be economical due to the fact that the flow from the spring sources can be conveyed through a gravity system.

The district does not have any master plan developed for the sector. Projects are selected on the basis of requests by the communities through various approaches.

Dolakha is a hilly district and majority of the water supply projects can be achieved through gravity type water transmission system right from the spring source. There are no pumping or pressure system are present within the district. The design of the infrastructure required for the rural water supply system has been standardized by DWSS. The standard designs are being used for the design and construction of the system components. The sanitation facilities that are available in Dolakha are conventional septic tank system. Basically, the District water supply and sanitation system comprises of the following infrastructure:

- Spring intakes of different types
- Transmission pipes: Mainly HDPE pipes with GI pipes in some places
- Distribution reservoirs mainly random rubble(RR) masonry or Ferro Cement type
- Reservoirs are mostly semi underground with CGI roofing.
- Break pressure tanks: They are made of RR masonry
- Distribution pipes: mainly HDPE pipes
- Public stand posts: RR masonry types
- Septic tank system

1.2 Vulnerability Assessments definitions

1.2.1 Identifying priority assets

Important criteria for identifying priority assets included:

- Infrastructure of national strategic importance
- Infrastructure of district strategic importance
- Infrastructure that has been impacted by past extreme events
- Infrastructure located in areas prone to past extreme events

In addition the potential aspects contributing to vulnerability were considered. Climate change vulnerability in the water supply and sanitation context is a function of a WATSAN asset system's exposure to climate effects, sensitivity to climate effects, and adaptive capacity:

- Exposure refers to whether the asset or system is located in an area experiencing direct impacts of climate change, such as temperature and precipitation changes, or indirect impacts, such as rise in flood levels.
- Sensitivity refers to how the asset or system fares when exposed to an impact.
- Adaptive capacity refers to the systems' ability to adjust to cope with existing climate variability or future climate impacts

Based on the above sets of criteria, two water supply systems and one sanitation facility has been selected as priority assets in Dolakha District. The detailed information on each asset is outlined in the baseline report for Dolakha district. Brief discussion on the asset and its components are outlined below.

1.2.2 Charikot WS System

The Charikot WS System is operated by Charikot WS and Sanitation Systems User Committee. Details of the system include:

- Source: Odare Spring
- Yield: 5/6 litres per second in dry season and 10/12 litres per second in wet season.
- No. of reservoirs: 4 that includes i) 125 cu-m ii) 95 cu-m iii) 200 cu-m and iv) 100 cu-m of stone masonry with 8” RCC core wall and constructed in different years.
- Treatment Plant: i) Sedimentation Tank-one ii) Slow Sand Filters- 3 Beds, two in operation and one in standby
- Pipeline system: Mostly HDPE pipes.
- Total Taps served – About 750 (all ½” connection and not metered) in Wards 1 and 10 of Bhimeswor Municipality (BM).
- Water Supply Hour: 1 hour in the morning and 1 hour in the evening during dry season and 2 hours in the morning and 2 hours in the evening during wet season

1.2.3 Old Dolakha WS System

The Old Dolakha WS System is operated by Water Supply & Sanitation Users Committee. Details of the system include:

- Source: Dharfe Spring and Gautam-Tole spring
- Yield: 1.7 litres per second in dry season and 4 litres per second in wet season.
- No. of reservoirs - 4 that includes i) 90 cu-m/Brick Masonry built in Year 1961 AD, ii)20 cu-m/Ferro cement built in Year 2008 AD, iii)20 cu-m/Ferro cement built in Year 2008 AD and iv) 50 cu-m/RCC built in Year 2009 AD
- Total Taps served (all ½” connections and not metered)—140 (Private) and-- 25 (Public) in mostly Wards 2,3 and 4 of Bhimeswor Municipality
- Pipe line system: During the construction of the project in 1961, all the pipelines were GI pipes and of size 2”(50 mm) dia. GI pipes laid during the construction have become too old and weak due to rusting and are leaking badly. Those pipes are slowly being replaced with HDPE pipes.
- Distribution Pipeline: Mostly old GI pipes and HDPE pipes
- Water Supply Hour: 1 hour in the morning and 1 hour in the evening during dry season and 2 hours in the morning and 2 hours in the evening during wet season

1.2.4 Kharibot Residential Septic Tank System

Kharibot is a highly densed residential area within Charikot and the residents rely on septic tank system. The septic tanks are not designed properly. They are of one chamber units and have no water tight base. Thus, they are constructed to perform as cesspools and the influent will be absorbed by the surrounding soil.

These septic tanks are susceptible to frequent overflows under any storm event and in addition to that these septic tanks are also contributed to the groundwater pollution. Communities have already observed huge contamination of springs and streams that are located within the community area. The contamination is mainly due to the seepage of sewage and overflows from the septic tanks under storm events. . In a recent consultation with the community confirmed that majority of the septic tanks were never desludged even though the sludge within the tank has reached the maximum level. The Bhimeswor Municipality has a suction vehicle which empties the septic tanks on regular basis and disposes the sludge from the septic tanks in a sludge pond which is far-off from the communities and is located in an isolated forest area. However, the municipality is finding difficulty in desludging the septic tanks as many of the properties are located in narrow-street and are not accessible to the suction tank. Due to this technical issue, many of the residents dispose their effluent with rich sludge into the surface water drains. In some parts of the community, the residents are allowed to open the septic tanks emergency overflow pipe and mix with the rainfall runoff under heavy downpour. The above two practices have a huge impact on the public health and hygiene.

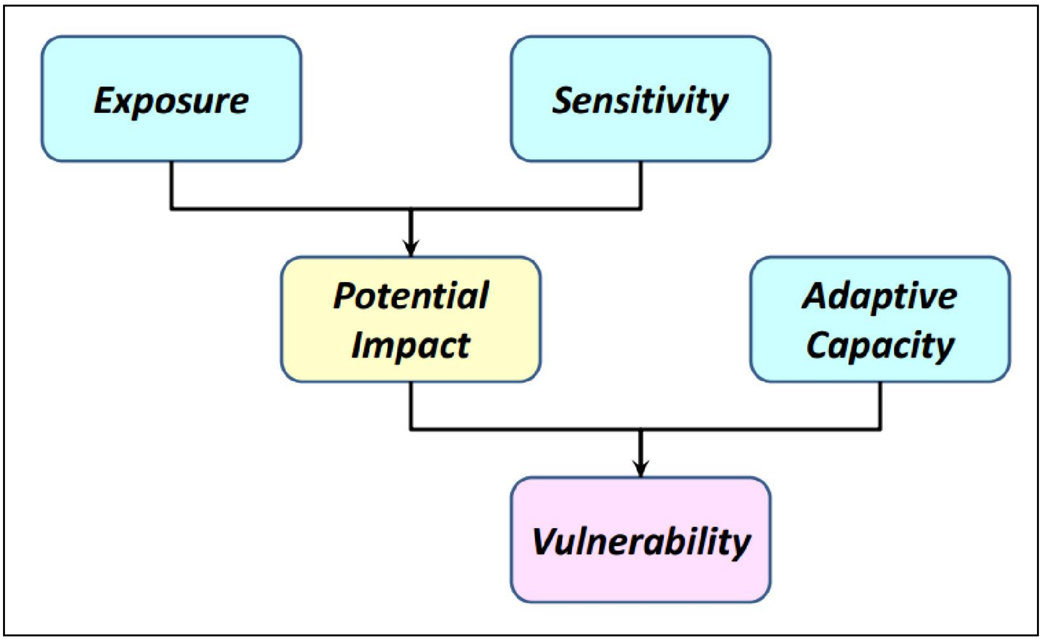
The Municipality is fully aware of this environmental and public health issue and are in the process of carrying out a project to address this problem by seeking help from a technical expert and financial support from Town Development Fund (TDF).

2 VULNERABILITY ASSESSMENT METHOD

2.1 VA Method

The VA method followed to assess the vulnerability of water and sanitation asset is widely used technique and tested in several parts of the world. Figure 2-1 outlines the process.

Figure 2-1: VA Process



Exposure refers to the extent to which an asset comes into contact with climate conditions or specific climate impacts. The greater the exposure, the higher the sensitivity to climate change. For example, assets located in historic landslide zones are more exposed and therefore more sensitive to increased rainfall and localized flood waters. The exposure also takes in to account the critical aspects such as the location of asset, intensity and duration of the climate threat towards the asset and the magnitude of the event.

Sensitivity is the degree to which an asset is directly or indirectly affected by changes in climate conditions (e.g., temperature and precipitation) or specific climate change impacts (e.g., increases in flood water levels). If a system is likely to be affected as a result of projected climate change, it should be considered sensitive to climate change. It takes in to account the age of the asset, materials used in the construction and its quality, levels of maintenance, any design considerations that protects the asset from any extreme climatic events.

Impact: Once the exposure and sensitivity assessment are performed, based on the assessment the severity of the impact is estimated using the guiding matrix as shown below:

Figure 2-2: Determining Impact

		Exposure of system to climate threat				
Sensitivity of system to climate threat		*Very Low*	*Low*	*Medium*	*High*	*Very High*
	Very High	*Medium*	*Medium*	*High*	*Very High*	*Very High*
	High	*Low*	*Medium*	*Medium*	*High*	*Very High*
	Medium	*Low*	*Medium*	*Medium*	*High*	*Very High*
	Low	*Low*	*Low*	*Medium*	*Medium*	*High*
	Very Low	*Very Low*	*Low*	*Low*	*Medium*	*High*

<u>Adaptive Capacity</u> refers to the availability of a system to accommodate or cope with climate change impacts with minimal disruption. This takes into account the range of available adaptation technologies and the funds that are available to meet such technologies, locals skills and knowledge base, management responsiveness and relevant polices that make such adaptation to happen and the locally available materials to address such adaptation.

<u>Vulnerability Scoring:</u> Based on the impact and adaptive capacity assessments, the vulnerability of the asset against the CC threats is estimated using the guiding matrix as shown below:

Figure 2-3: Determining Vulnerability

		Impact				
Adaptive Capacity		*Very Low* *Inconvenience (days)*	*Low* *Short disruption to system function (weeks)*	*Medium* *Medium term disruption to system function (months)*	*High* *Long term damage to system property or function (years)*	*Very High* *Loss of life, livelihood or system integrity*
	Very Low *Very limited institutional capacity and no access to technical or financial resources*	*Medium*	*Medium*	*High*	*Very High*	*Very High*
	Low *Limited institutional capacity and limited access to technical and financial resources*	*Low*	*Medium*	*Medium*	*High*	*Very High*
	Medium *Growing institutional capacity and access to technical or financial resources*	*Low*	*Medium*	*Medium*	*High*	*Very High*
	High *Sound institutional capacity and good access to technical and financial resources*	*Low*	*Low*	*Medium*	*Medium*	*High*
	Very High *Exceptional institutional capacity and abundant access to technical and financial resources*	*Very Low*	*Low*	*Low*	*Medium*	*High*

2.2 Suitability of VA Method to WATSAN Sector

The approach used for this vulnerability assessment is consistent with other methodological guidelines prepared by UNEP and Peking University (UNEP, 2009) as well as other international VA processes that are widely used in several projects across the globe.

Vulnerability assessment is a tool for identifying potential risks to water resources and sanitation facilities, providing decision-makers with an early warning signal about the need to monitor potential variation over time. This is important in detecting threats early as well as formulating and implementing measures to reduce negative impacts. Vulnerability assessment of water resources and sanitation facilities will also identify gaps in existing information and the appropriate indicators and management measures required for the government to gather such information. Moreover, the assessment enhances public awareness about potential threats.

The current vulnerability assessment process followed for WATSAN sectors is to better understand the existing status of water and sanitation system under the prevailing conditions and to ascertain the most dominant factors that influence vulnerability. The current process helps the decision-makers with options to evaluate and modify existing policies and to implement measures to improve water resource management and sanitation facilities. Specifically, the assessment is suitable and aims the WATSAN issues such as:

- Assess the vulnerability of existing freshwater resources to threats and sanitation facilities that are prone CC threats, and its impact on development options, human well-being and the environment;
- Identify the potential impacts of climate change on WATSAN and ecosystems, and assess the current adaptive capacity of the national water sector;
- Create a knowledge base of scientific data and information on available surface and groundwater sources and the water demand of each sector;
- Evaluate the impacts of environmental change in terms of water resource stress and identify management challenges such as identifying alternative sources;
- Develop the knowledge, policy options;
- Identify gaps in data and research and recommend needs for further studies; and
- Examine water and sanitation issues and functions in selected surface and groundwater basins.

2.3 Climate Change Threat Profiles

The climate change threat profiles for Dolakha District were prepared by the Hydrological Modeling teams and the information passed on to all the experts prior to the field visit. The threat profile is annexed in Annexure 1. The climate change threat profiles for Dolakha were studied and their relevance to the WATSAN sector is outlined below:

2.3.1 Increase/decrease in precipitation

Looking in to the threat profile for precipitation the following conclusions can be drawn:

- Duration of extreme rainfall events with high intensity will occur more often than before. For example, 50mm/hr rainfall intensity has duration of 12 minutes; in future 100mm/hr rainfall intensity will fall for the same duration.
- Increase in precipitation frequency and volume can be foreseen in future, this may trigger more landslides. Precipitation vs annual recurrence interval curve shows an increase in precipitation occurs more frequently. More precipitation can be seen in the catchment than

that was never experienced before. For example in the past 250mm of precipitation used to occur at every 100 years but in future it can be seen at every 40 years.

- On an average the rainfall intensities will increase by 84%.

2.3.2 Increase in temperature

Looking in to the threat profile for temperature the following conclusions can be drawn:

- Increase in average maximum temperature of up to 1.850C.
- More intense temperatures occur more frequently and the duration of such intense temperatures will be longer. This means, a temperature of 300C will be spread throughout the year for longer durations, this in turn triggers longer summer period than before.

2.3.3 Increase in flows

Increased flows due to increase in rainfall is expected. Increase in flood water levels in the nearest river has no impact on WATSAN sector for Dolakha District.

3 VULNERABILITY ASSESSMENT RESULTS

The results of the vulnerability assessment are outlined in Annexure 2 of this report. However, a brief vulnerability assessment of two assets within Dolakha District is outlined below.

3.1 Old Dolakha Water Supply System

3.1.1 Asset Description

The following table describes the important aspects of the Old Dalkha water supply system. Figure 3-1,

Figure 3-2 and Figure 3-3 show a typical view of the pipeline and reservoir system.

Asset Age	48 years
Operator	Water Supply and Sanitation Users' Committee/Dolakha, Ward-2, Bhimeswor Municipality
Source	Natural Springs – Not well protected
Transmission Pipeline	2-3 Km, a section of pipe is laid along the historic landslide area(Previously 2" Dia. GI pipe now replaced by 65 mm dia. HDPE pipe)
Reservoirs	1 Brick Masonry(Old)/80 cu-m +2 Ferro Cement(New) /20 cu-m each + 1 RCC(New)/50 cu-m
Supply Hours	2-3 hrs. in the morning in wet season 1 hr. in the morning in dry season
Total Connections	141 Private + 20 Public
Water Treatment Plant	None at the moment
Distribution Pipeline	Approx. 4 Km
Coverage	Dolakha Township-Wards 2,3 and 4 of Bhimeswor Municipality (Source: Old Dolakha WUC)

Figure 3-1: Hanging transmission pipeline along the historic landslide area

Figure 3-2: Another view of hanging transmission pipeline

Figure 3-3: Tilinchowk reservoir system

3.1.2 Vulnerability assessment of transmission pipeline

The following section outlines the decisions undertaken in setting the levels of threat, exposure, sensitivity and adaptive capacity for the transmission pipeline.

Threat: Increased Intensity of Rainfall

The following threats have been identified as likely to impact on the transmission pipeline:

- As per the threat profile (see Annexure 1), on an average rainfall intensities will increase by 70%
- Rainfall events occur more frequently than before
- Increased risk of landslides – transmission and reservoirs at risk

Exposure: HIGH

The exposure was ranked as high for the following reasons:

- Location: The existing transmission pipeline is laid along the historic landslide area and is also exposed to high intensity rainfall zone
- Duration: Longer duration rainfall events occur more frequently within the asset area
- Intensity: High intensity rainfall occurs more frequently
- Aspect: Steep slopes brings more rainfall runoff to the site and causes more landslides

Sensitivity: HIGH

The sensitivity was ranked as high for the following reasons:

- Material: Transmission pipelines are of HDPE
- Design & Construction: Poorly laid transmission pipelines
- Levels of Maintenance: Poorly maintained transmission pipelines
- Protective measures: No protective measures for transmission pipelines provided

Impact: HIGH

From the guiding matrix, it can be seen that the impact is HIGH as well. The justification for high impact is as follows:

- Under severe storm condition, increased flow would trigger more landslides that would damage/in some cases the transmission pipeline may collapse.
- Due to the sudden collapse of pipeline along the expected landslide zone, disruption of water supply services can be foreseen to the general public.
- Disruption to day to day livelihood.
- Disruption to businesses and industries.
- Public and others to rely on private water supply arrangement that would cost more money to the end-user.

Adaptive Capacity: MEDIUM

The adaptive capacity was ranked as medium for the following reasons:

- The local authorities are provided with adequate funds for development projects
- Advanced technical capabilities are readily available through local consulting firms

- Local construction material readily available

Vulnerability Scoring: HIGH

As per the below guiding matrix, the vulnerability for the Old Dolakha transmission pipelines is HIGH.

		Impact				
		Very Low Inconvenience (days)	Low Short disruption to system function (weeks)	Medium Medium term disruption to system function (months)	High Long term damage to system property or function (years)	Very High Loss of life, livelihood or system integrity
Adaptive Capacity	Very Low Very limited institutional capacity and no access to technical or financial resources	Medium	Medium	High	Very High	Very High
	Low Limited institutional capacity and limited access to technical and financial resources	Low	Medium	Medium	High	Very High
	Medium Growing institutional capacity and access to technical or financial resources	Low	Medium	Medium	High	Very High
	High Sound institutional capacity and good access to technical and financial resources	Low	Low	Medium	Medium	High
	Very High Exceptional institutional capacity and abundant access to technical and financial resources	Very Low	Low	Low	Medium	High

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3.1.3 Vulnerability assessment on Tilinchowk storage reservoirs

Threat: Increased flow due to increases rainfall

The following threats have been identified as likely to impact on the Tilinchowk storage reservoirs:

- Increased flow from the catch-basin to intake point and then on to reservoirs due to increased rainfall
- Rainfall events occur more frequently and in larger volume

Exposure: HIGH

The exposure was ranked as high for the following reasons:

- Duration: Longer duration rainfall events with high intensity will occur more frequently that brings more flows and sediments.
- Location: The intake and the storage reservoir are located just u/s of the wide catchment basin that could bring flash flows due to increased high-intensity rainfall.
- Intensity: Increase in precipitation frequency and volume would make the location more vulnerable for flash flows that would trigger shock-loads at the reservoir.

Sensitivity: MEDIUM

The sensitivity was ranked as medium for the following reasons:

- Materials used in the construction of intake and reservoirs are of above adequate level.
- The design and construction of reservoir are adequate and safe. Regular maintenance at the reservoir is performed by the authorities.

- There were no protective measures to control the excessive sediments that arrive at the reservoirs during the increased rainfall and flow event.

Impact: HIGH

From the guiding matrix, it can be seen that the impact is HIGH as well. The justification for high impact is given below:

- Since there is no WTP between the source and the reservoir, the heavily sedimented water will reach the consumers which would have huge impact on the public health.
- Under severe flow conditions, the increased flow affects the functionality of the existing reservoirs.
- Affects the storage capacity due to sediment deposition.
- Need more frequent O&M tasks which in turn raise the O&M costs which is a huge burden on the operators and the end-users.
- The existing distribution system gets clogged during the off-peak time and needs more attention to unclog the sediments for effective and efficient operation of the system.

Adaptive Capacity: MEDIUM

The adaptive capacity was ranked as medium for the following reasons:

- The local authority is supported by community funds to enhance any water supply assets to provide uninterrupted water supply to the residents of the community.
- Advanced technical capabilities are readily available through local consulting firms to design more sustainable assets with climate resilient approach.

Vulnerability Scoring: HIGH

As per the below guiding matrix, the vulnerability for the Old Dolakha reservoirs is HIGH.

		Impact				
		Very Low Inconvenience (days)	Low Short disruption to system function (weeks)	Medium Medium term disruption to system function (months)	High Long term damage to system property or function (years)	Very High Loss of life, livelihood or system integrity
Adaptive Capacity	Very Low Very limited institutional capacity and no access to technical or financial resources	Medium	Medium	High	Very High	Very High
	Low Limited institutional capacity and limited access to technical and financial resources	Low	Medium	Medium	High	Very High
	Medium Growing institutional capacity and access to technical or financial resources	Low	Medium	Medium	High	Very High
	High Sound institutional capacity and good access to technical and financial resources	Low	Low	Medium	Medium	High
	Very High Exceptional institutional capacity and abundant access to technical and financial resources	Very Low	Low	Low	Medium	High

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3.2 Kharibot Residential Area Septic Tank System

3.2.1 Asset Description

The following table describes the important aspects of the Kharibot residential area septic tank system. Figure 3-4 and Figure 3-5 show a typical view of the crowded residential area of Kharibot town.

Area	Densely populated area
Residential type	Low to medium income group area
Type of sanitation facilities	Septic tanks but acts as cess-pit type due to no concrete bottom
Issues with the system	Frequent overflow from septic tanks Could be a major contributor to groundwater and local streams (further research required to confirm)
Operator	Operated by the local municipality

Figure 3-4: Kharibot residential area

Figure 3-5: Another view of residential area

3.2.2 Vulnerability assessment on Kharibot residential sanitation system

Threat: Increased Intensity of Rainfall

The following threats have been identified as important for the Kharibot residential sanitation system:

- As per the threat profile (see Annexure 1), on an average rainfall intensities will increase by 70%
- Rainfall events occur more frequently than before
- Increased number of spill/overflow events from ST's

- Increased frequency of overflow from ST's
- Increased volume of overflow from ST's

Exposure: HIGH

The exposure was ranked as high for the following reasons:

- Location: Residential area located in the medium – high intensity rainfall zone
- Duration: Longer duration rainfall events occur more frequently
- Intensity: High intensity rainfall occurs more frequently
- Aspect: South facing slope brings more rainfall runoff in to the site

Sensitivity: HIGH

The sensitivity was ranked as high for the following reasons:

- Location: Residential area located in the medium – high intensity rainfall zone
- Duration: Longer duration rainfall events occur more frequently
- Intensity: High intensity rainfall occurs more frequently
- Aspect: South facing slope brings more rainfall runoff in to the site

Impact: HIGH

From the guiding matrix, it can be seen that the impact is HIGH as well. The justification for high impact is given below:

- ST's fail to function efficiently and effectively.
- More frequent overflows can be observed due to increased precipitation.
- More frequent pollution to the nearest streams.
- Public and children will come in contact with the sewage more frequently.
- Increases the health risks to the residents.
- Increased health care costs and burden on the public health system due to increased visits by sick public.
- Decreased life expectancy due to increased morbidity and child mortality.
- Increased sick leave and lower work productivity.
- Decreased school attendance
- Decreased tourism.

Adaptive Capacity: MEDIUM

The adaptive capacity was ranked as high for the following reasons:

- The local authority has Town Development Fund (TDF) for development projects.
- The local authority has already identified this issue as a future threat and have done a detailed design for comprehensive sewerage system
- Technical capabilities are readily available within the authority
- Local construction material readily available
- Community volunteers are available to support during any crisis.

<u>Vulnerability Scoring: HIGH</u>

As per the below guiding matrix, the vulnerability for the Old Dolakha transmission pipelines is HIGH.

		Impact				
		Very Low Inconvenience (days)	*Low* Short disruption to system function (weeks)	*Medium* Medium term disruption to system function (months)	*High* Long term damage to system property or function (years)	*Very High* Loss of life, livelihood or system integrity
Adaptive Capacity	*Very Low* Very limited institutional capacity and no access to technical or financial resources	Medium	Medium	High	Very High	Very High
	Low Limited institutional capacity and limited access to technical and financial resources	Low	Medium	Medium	High	Very High
	Medium Growing institutional capacity and access to technical or financial resources	Low	Medium	Medium	High	Very High
	High Sound institutional capacity and good access to technical and financial resources	Low	Low	Medium	Medium	High
	Very High Exceptional institutional capacity and abundant access to technical and financial resources	Very Low	Low	Low	Medium	High

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4 DOLAKHA DISTRICT VULNERABILITY SUMMARY

4.1 Summary of VA Results

4.1.1 Old Dolakha Water Supply System

The table below summarises the vulnerability assessment of the Old Dolakha water supply system. The analysis shows that the most vulnerable components of the system are the transmission pipleline and reservoirs. Both were ranked as highly vulnerable to climate change induced increase in rainfall and flows.

INTAKE POINT - NATURAL SPRING					
THREAT	EXPOSURE	SENSITIVITY	IMPACT	ADAPTATION CAPCITY	VULNERABILITY SCORE
INCREASED RAINFALL	LOW	MEDIUM	MEDIUM	MEDIUM	**MEDIUM**
INCREASED TEMPERATURE	MEDIUM	MEDIUM	MEDIUM	MEDIUM	**MEDIUM**
TRANSMISSION PIPELINE					
THREAT	EXPOSURE	SENSITIVITY	IMPACT	ADAPTATION CAPCITY	VULNERABILITY SCORE
INCREASED RAINFALL	HIGH	MEDIUM	HIGH	MEDIUM	**HIGH**
INCREASED FLOW	HIGH	HIGH	HIGH	MEDIUM	**HIGH**
RESERVOIRS					
THREAT	EXPOSURE	SENSITIVITY	IMPACT	ADAPTATION CAPCITY	VULNERABILITY SCORE
INCREASED RAINFALL	HIGH	MEDIUM	HIGH	MEDIUM	**HIGH**
INCREASED FLOW	HIGH	HIGH	HIGH	MEDIUM	**HIGH**

4.1.2 Kharibot Septic Tank System

The table below summarises the vulnerability assessment of the Kharibot septic tank system. The analysis shows that the system is ranked as highly vulnerable.

THREAT	EXPOSURE	SENSITIVITY	IMPACT	ADAPTATION CAPCITY	VULNERABILITY SCORE
INCREASED RAINFALL	HIGH	HIGH	HIGH	MEDIUM	**HIGH**

4.2 Most Vulnerable Assets and Components

Based on the VA performed within Dolakha District, the following conclusions can be made on the assets and components:

Old Dolakha WS System

THREAT	DESCRIPTION	IMPACT	WHY IT IS VULNERABLE
Reservoirs			
Increased Flow	Increased flow events occur more frequently and in huge volume	Brings more sediments to the source	More sediments with organic matter reaching the residents would cause serious health

THREAT	DESCRIPTION	IMPACT	WHY IT IS VULNERABLE
			damages to the consumers.
TRANSMISSION PIPELINE			
Increased Rainfall	On an average rainfall intensities will increase by 70%. Rainfall events occur more frequently	Triggers more landslides	The failure causes serious disruption to water supply and takes several days to reinstate the same.

Kharibot Residential Septic Tank System

THREAT	DESCRIPTION	IMPACT	WHY IT IS VULNERABLE
Increased Rainfall	On an average rainfall intensities will increase by 70%. Rainfall events occur more frequently	More frequent overflows from the septic tank that may overflow through the streets and also pollutes the groundwater and the nearest streams	Frequent overflows from septic tank causes public health and hygiene issues.

4.3 Lessons and Application to Other Assets

Dolakha district has both urban and rural culture. The district has both rural type and urban type water supply system that gives an opportunity to understand the impacts of CC threats on both type of assets. The same impacts, vulnerability and adaptation plans can be applied to wider urban and rural areas within the district. Majority of the water supply and sanitation assets are experiencing similar sort of exposure, sensitivity towards the CC threats and the adaptive capacity of the local authorities towards emergency management is more or less the same. This means, one asset in each sector and one assessment with varied CC threats can be applied in similar sector. Both water supply and sanitation sectors are struggling with lack of funds, inadequate skills and support to combat with CC related threats and events. The water supply sector is lacking control of sediments that are arriving at the intake and reservoir system. This can be achieved through simple construction of intake structure with proper screening facilities. In addition to this, some of the existing transmission pipelines are not well protected from the open environment which is extremely vulnerable to CC events.

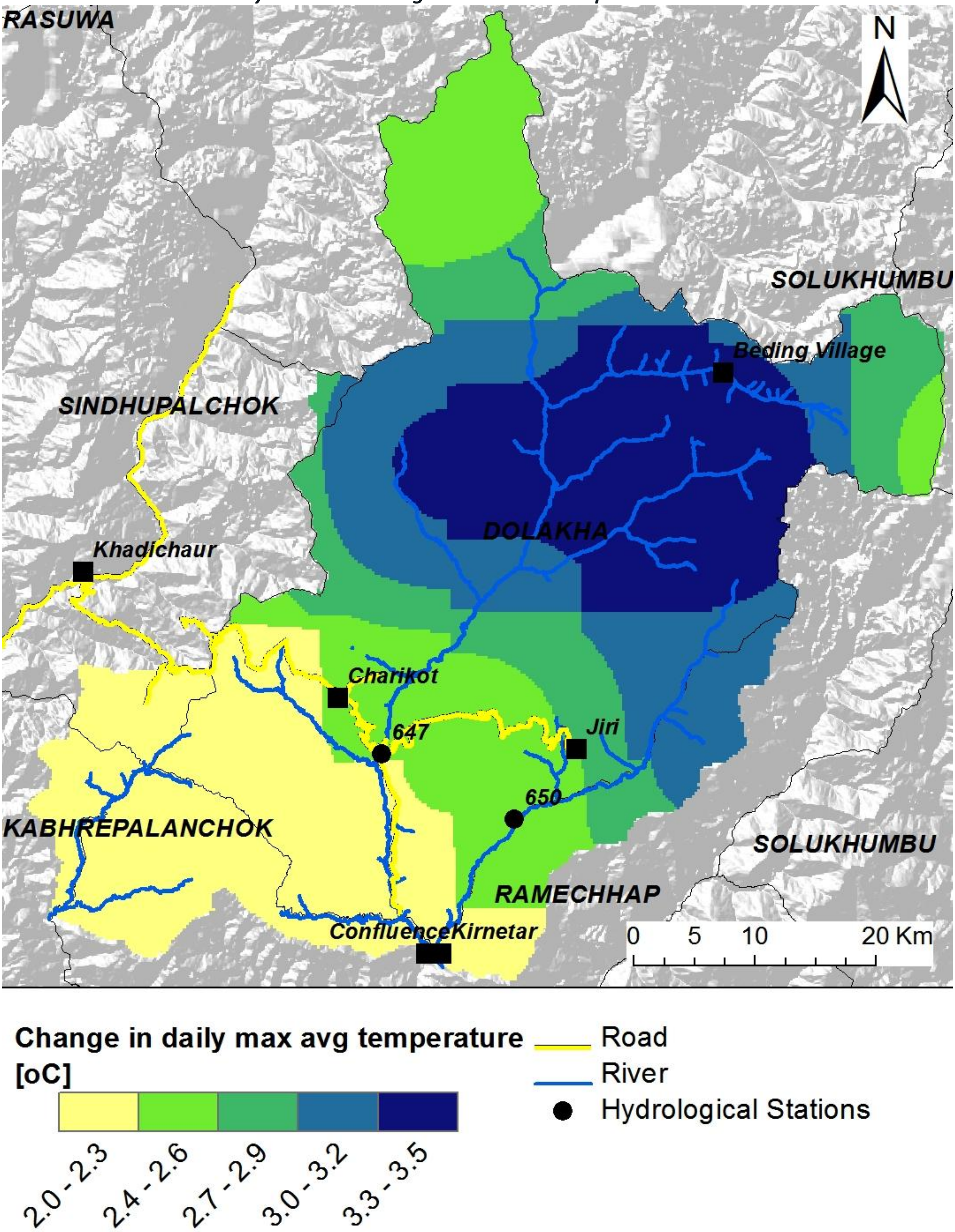
Similarly, in the sanitation sector within Dolakha, the majority of the residents both in rural and urban areas rely on septic tank systems. The problems associated with the operation, maintenance and frequent overflows under severe storm event are the common issues. In view of this, Kharibot residential area has been chosen to study the issues and tested the septic tank system against the varied CC threats and presented the vulnerability scoring. The same approach and adaptation plans can be applied across Dolakha.

ANNEXES

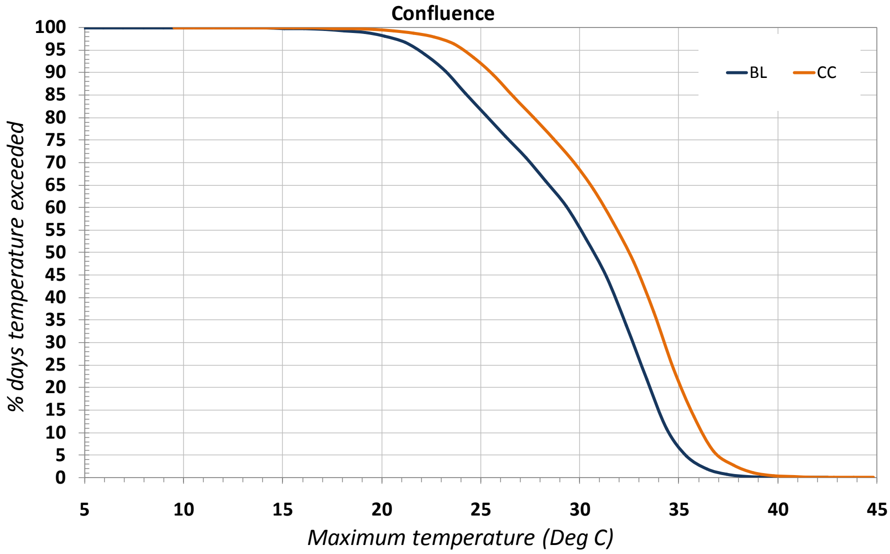
ANNEXURE 1: THREAT PROFILE

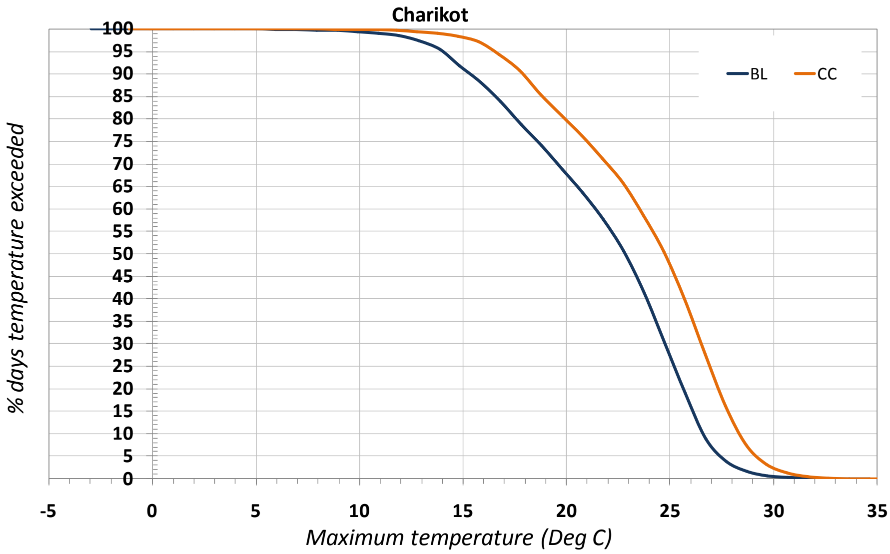
A. INCREASING MAXIMUM TEMPERATURES

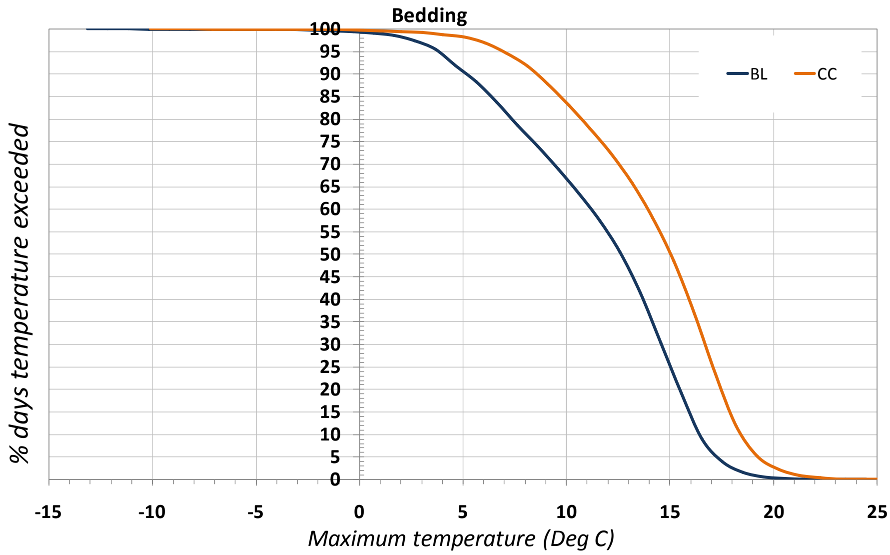
Dry season average maximum temperatures



Daily maximum temperature exceedance curves

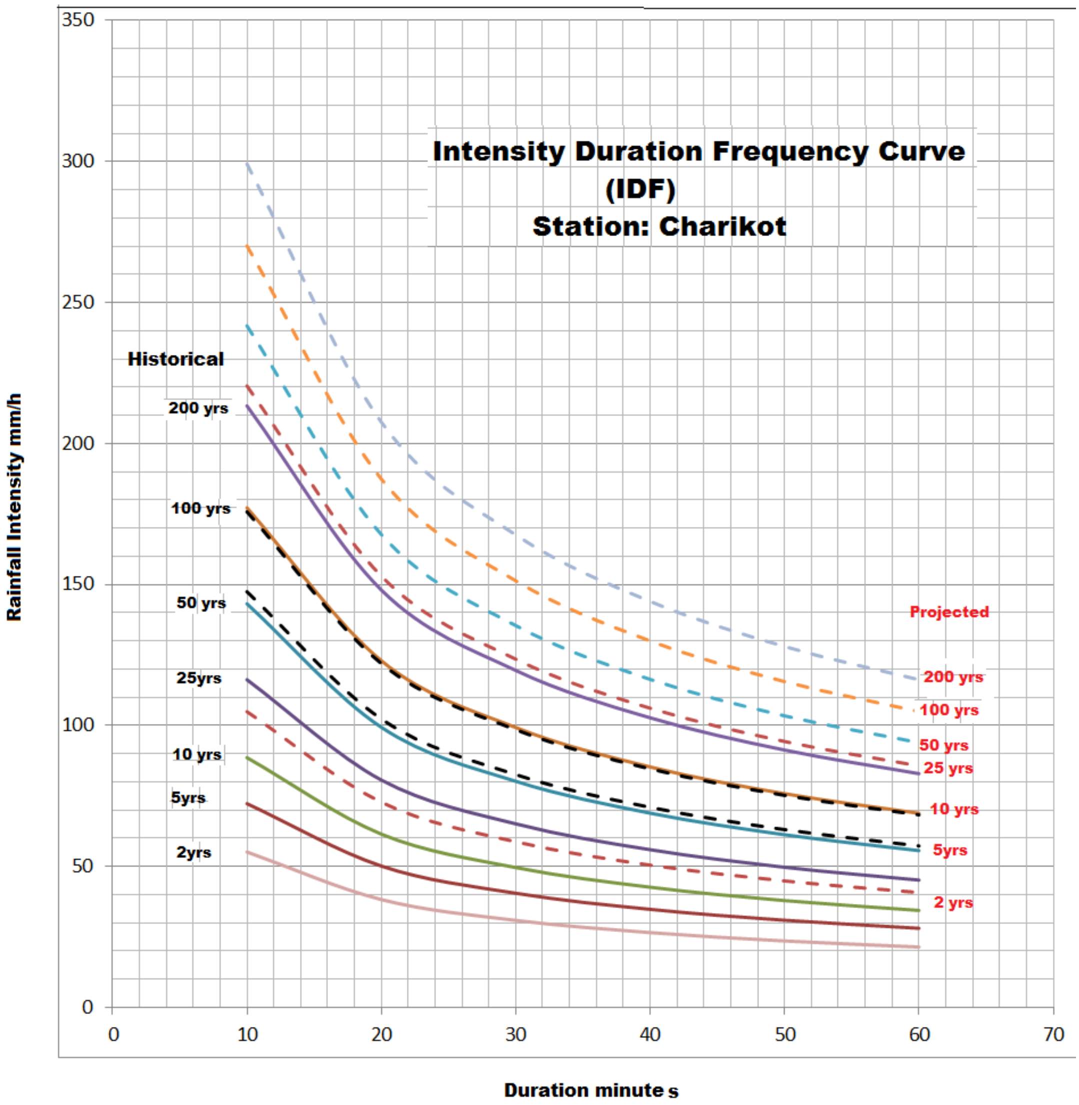






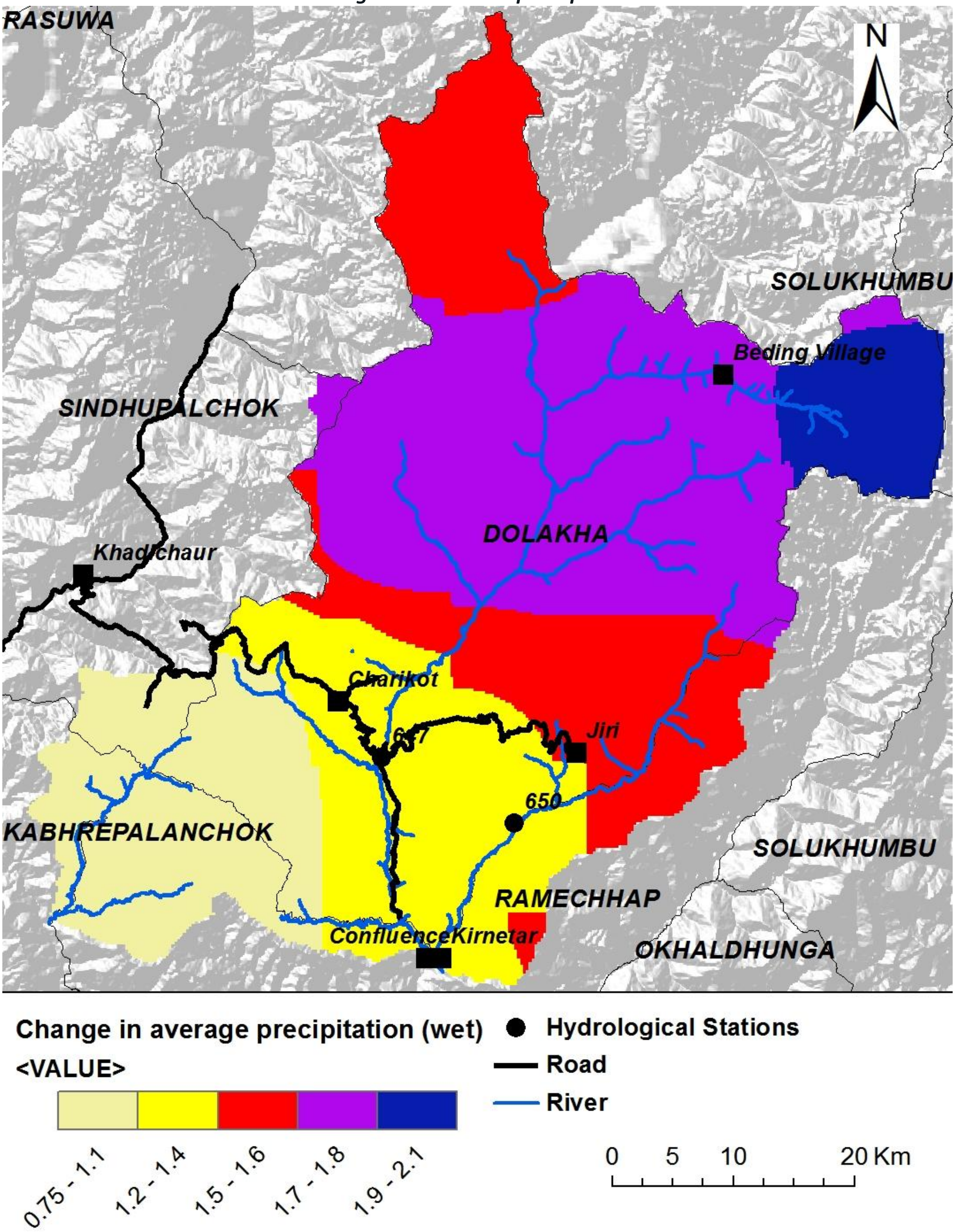
B. INCREASING INTENSITY OF RAINFALL

Intensity Duration Frequency (IDF) curves

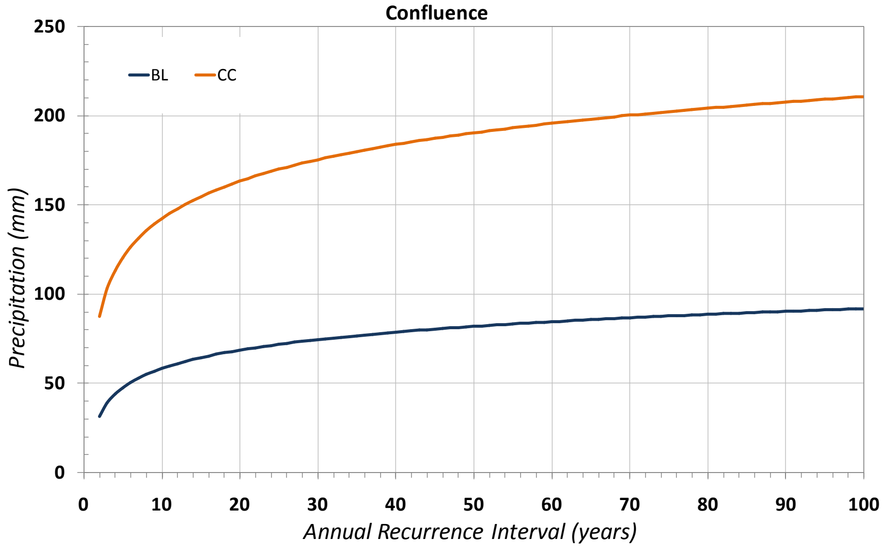


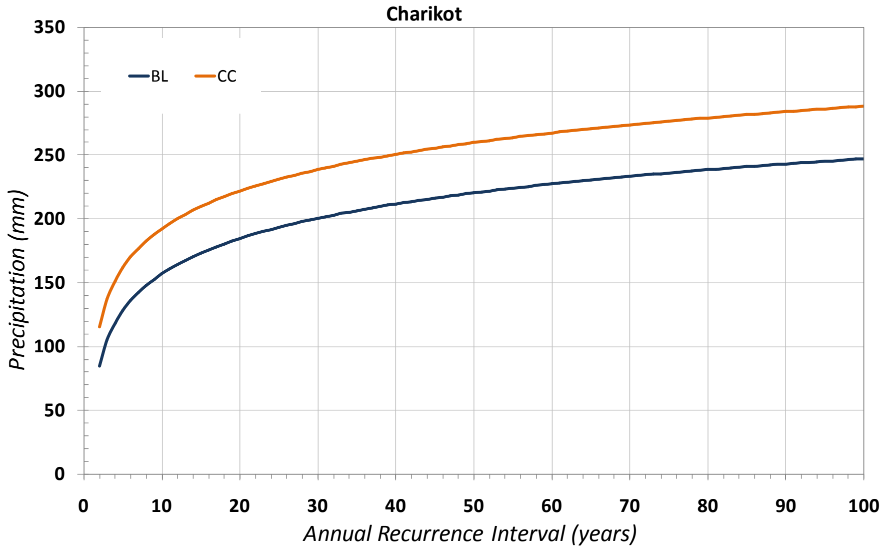
C. INCREASING NUMBER OF EXTREME RAINFALL EVENTS

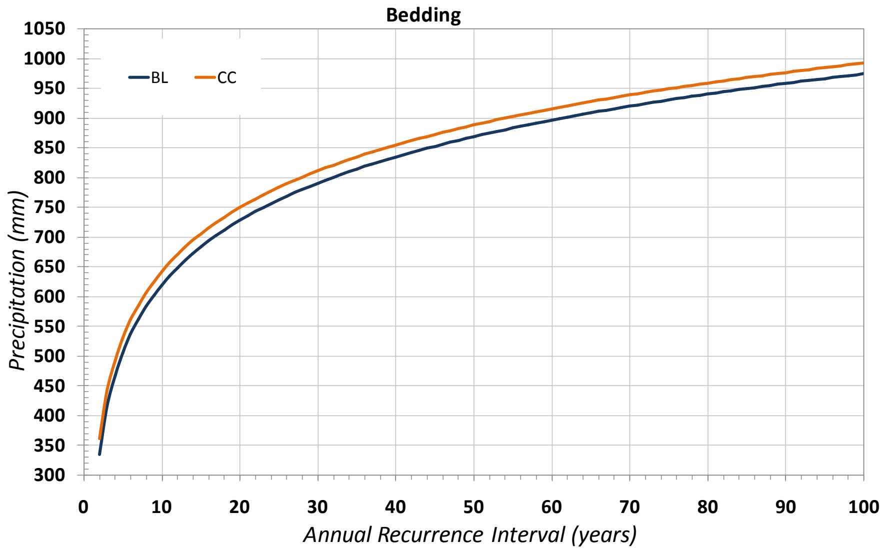
Average wet season precipitation



Rainfall return periods

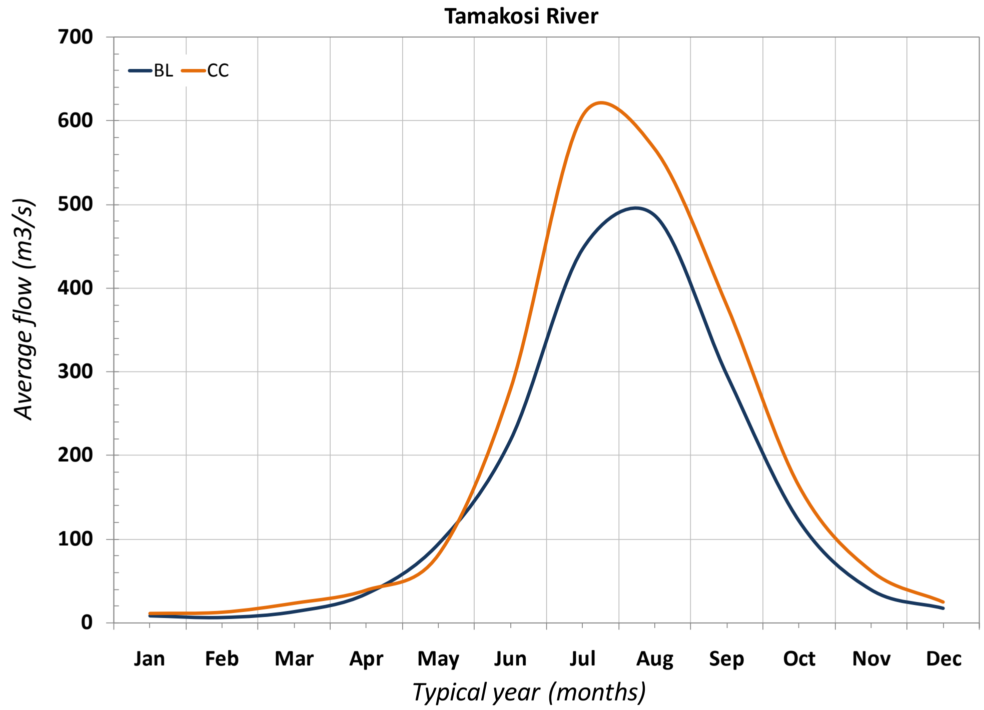


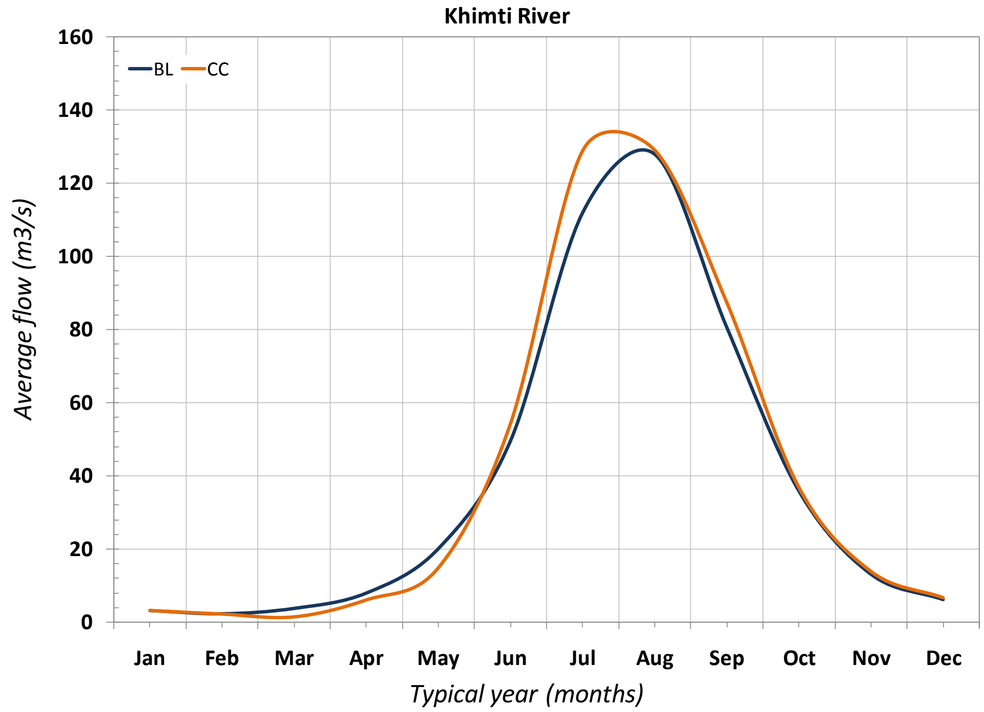




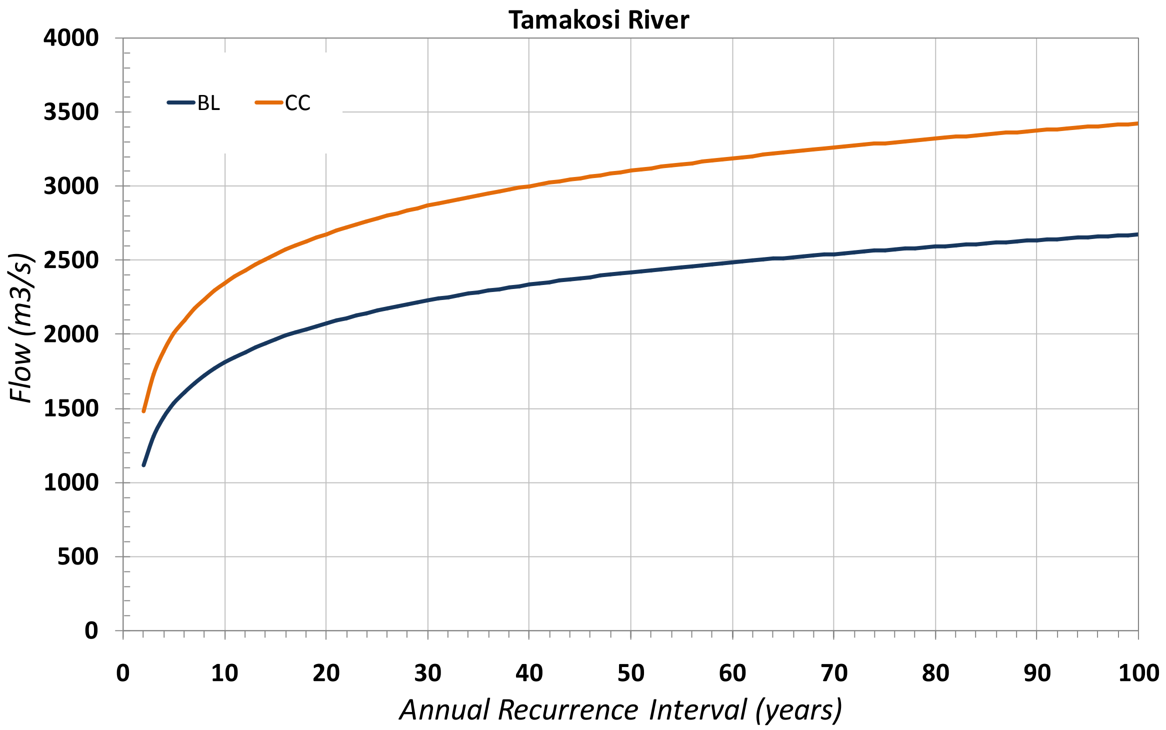
D. INCREASING FLOW AND WATER LEVELS

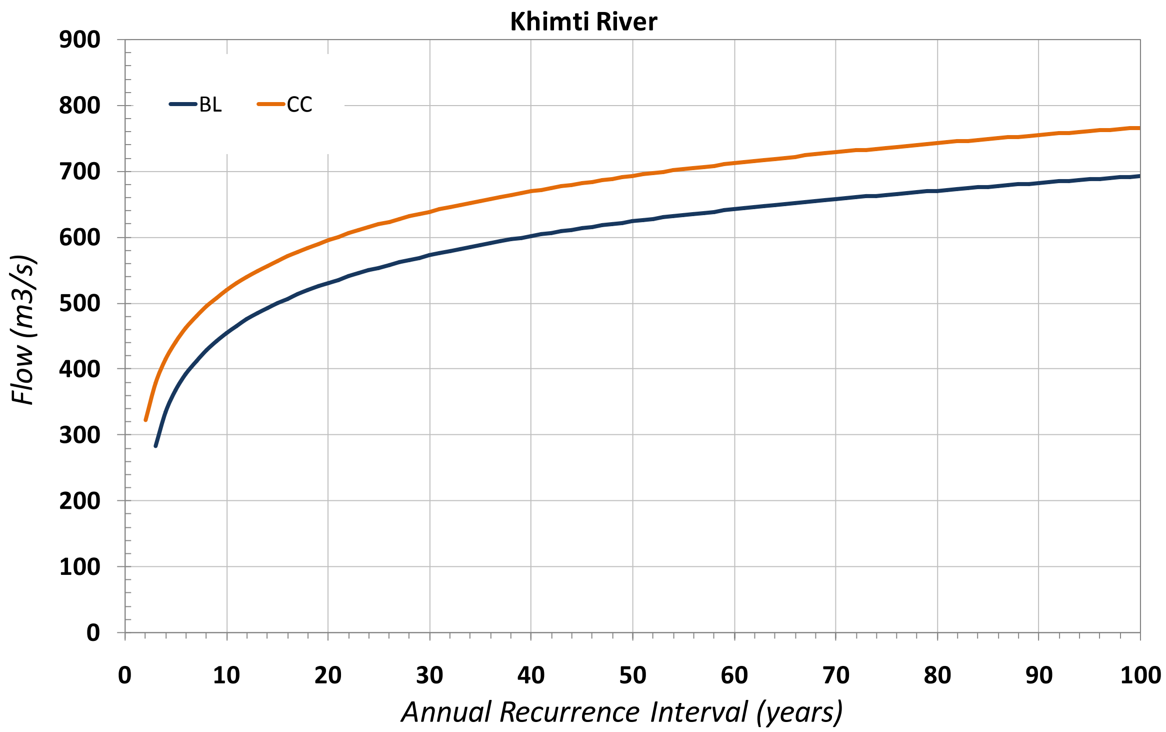
Hydrographs



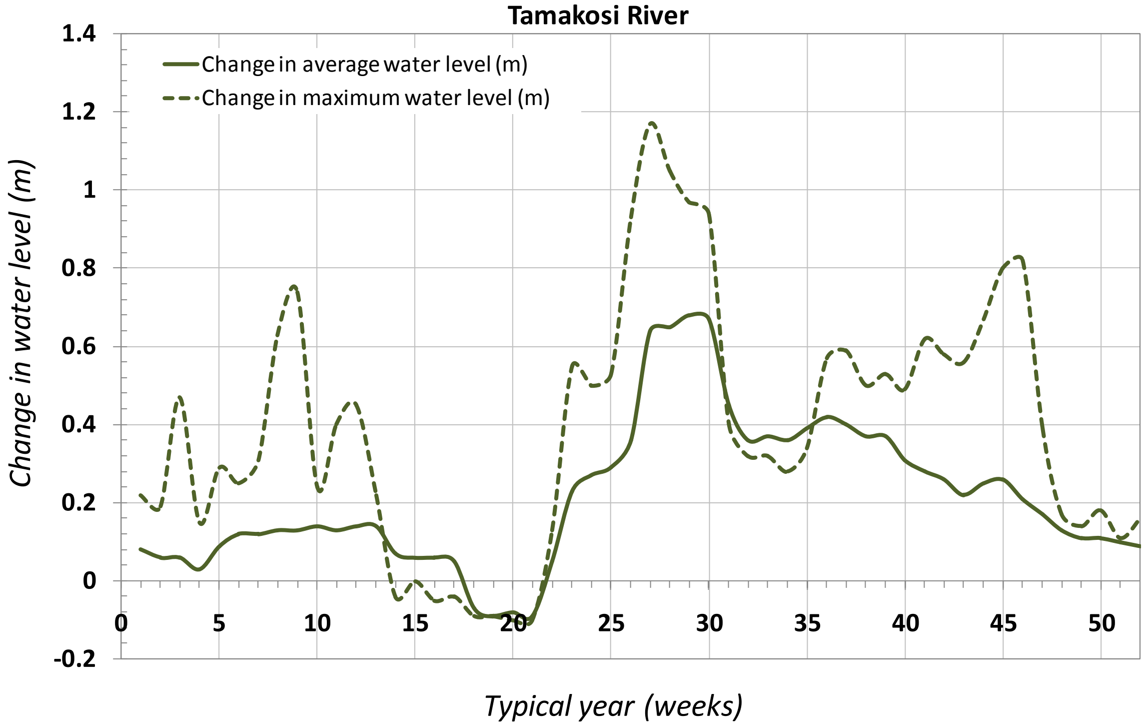


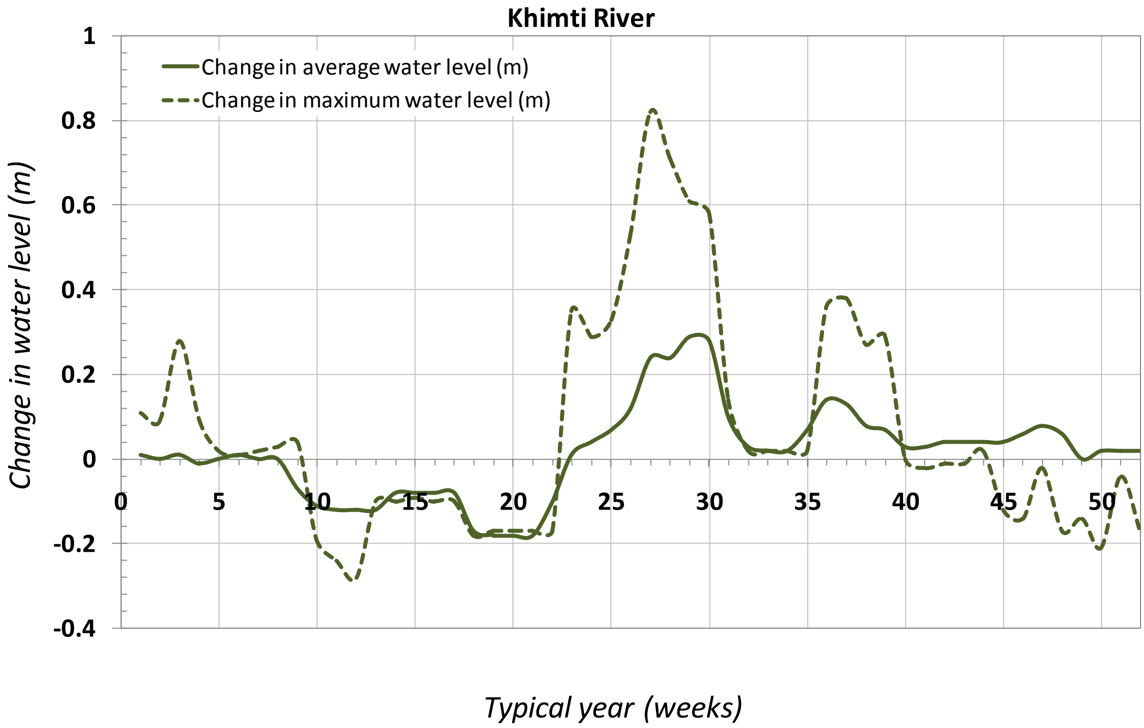
Discharge return periods



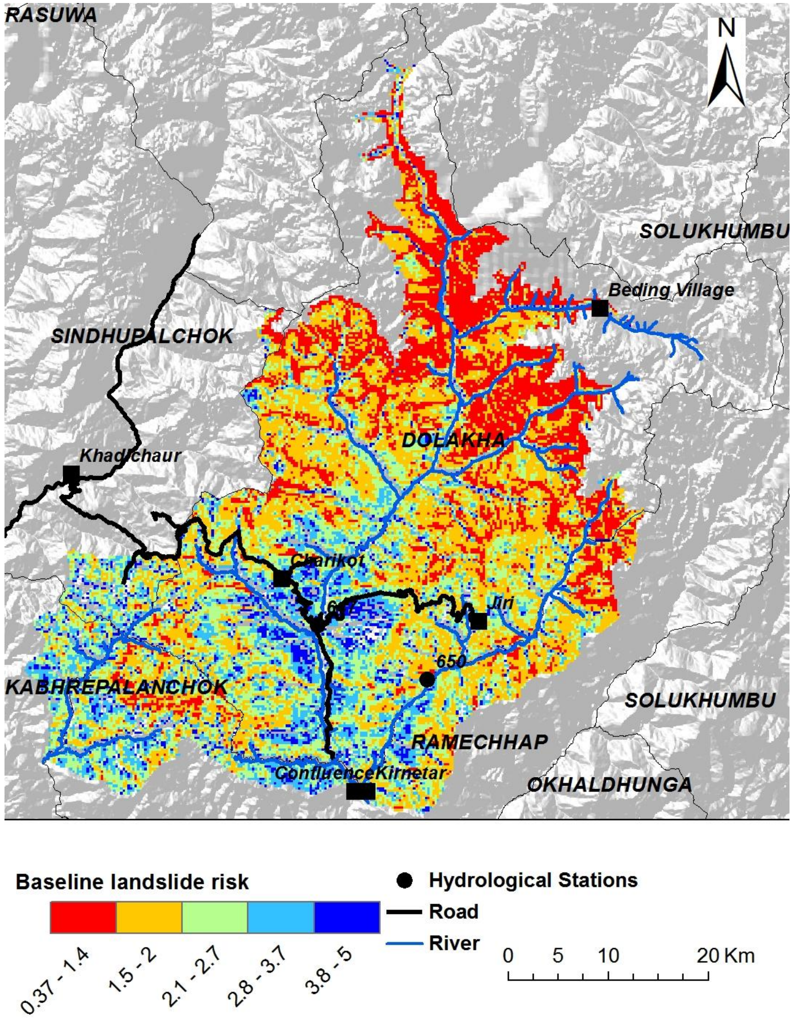


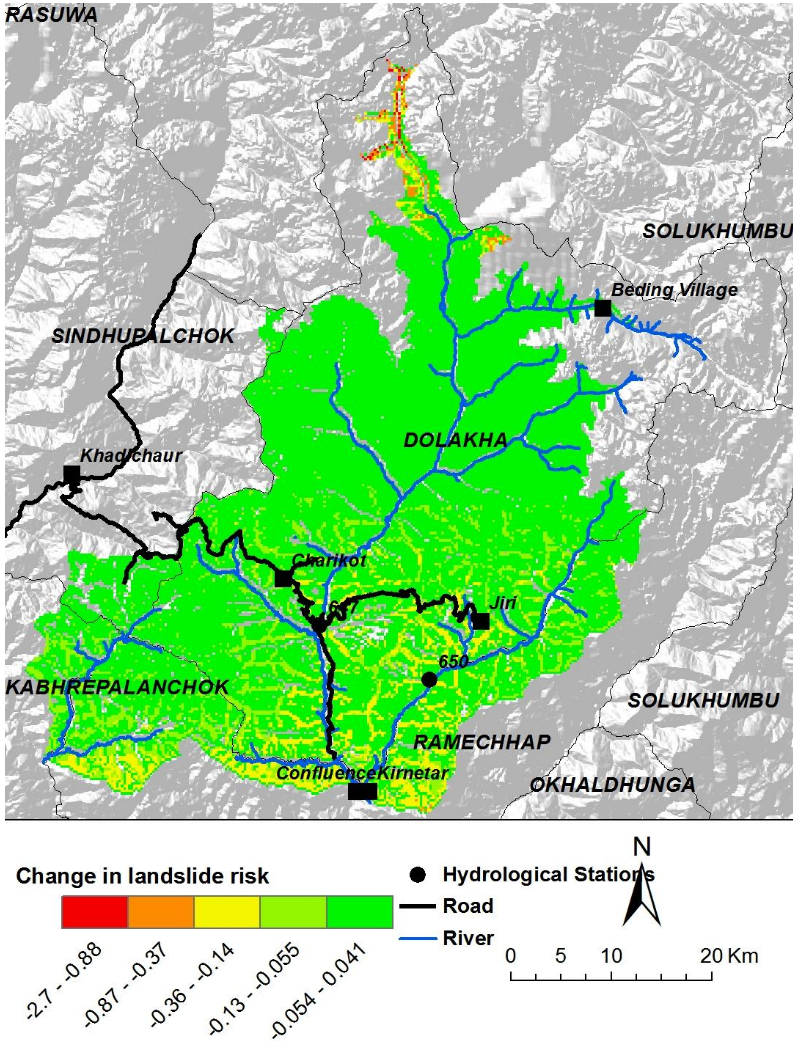
Water levels





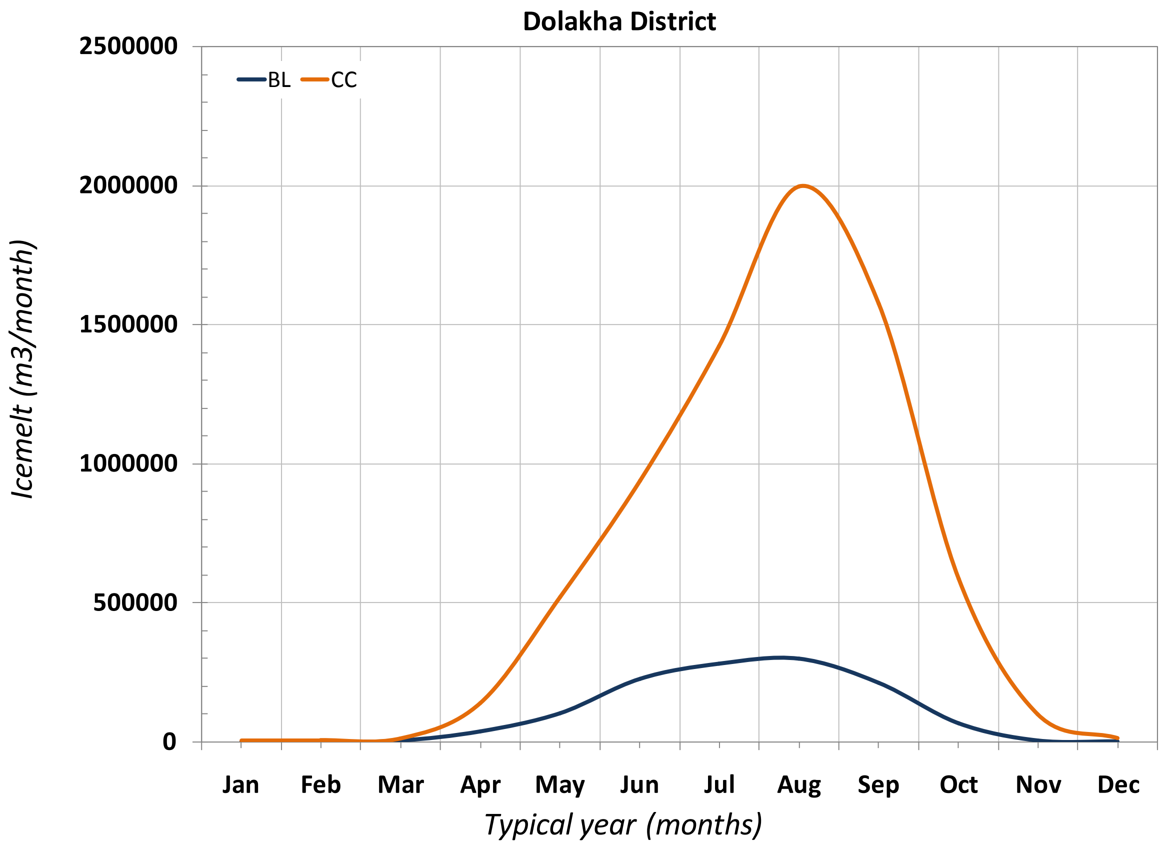
E. INCREASING RISK OF LANDSLIDES IN THE DISTRICT





F. GREATER LIKELIHOOD OF GLOFS

- Increasing temperatures
- Increasing rainfall (particularly at high elevations)
- Increasing ice melt



ANNEXURE 2: VA MATRIX

Asset: Charikot Water Supply System

Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
	written description of how the threat relates to the asset	*refer to table*			*written explanation of what the impact is, and why it was scored (high, med, low)*	*refer to table*	*refer to table*
Change and shift in regular climate							
Increase in precipitation	On an average intensity of rainfall increases by 1.3.	H[1 2 3 4]	L[5 6]	M	▪ Under severe precipitation scenario, the increased flow affects the existing WTP capacity and reduces the treatment quality. ▪ May attract more robust treatment technology and additional sediment beds. ▪ May need either additional storage at WTP or reservoir point. ▪ Transmission pipelines may get exposed along the alignment due to erosion/scoring caused by increased precipitation. This would leave the pipelines exposed to	M[7 8]	M

[1] Duration: Long duration of rainfall events with high intensity will occur more frequently.

[2] Location: Located in the high-intensity rainfall zone

[3] Intensity: Precipitation *vs* annual recurrence interval curve shows an increase in precipitation occurs more frequently. More precipitation can be seen in the catchment than that was never experienced before. For example in the past 250mm of precipitation used to occur at every 100 years but in future it can be seen at every 40 years.

[4] Located on South facing slope this means more susceptible to longer duration precipitation.

[5] Materials used in the construction of WTP, reservoirs and transmission pipelines are of above acceptable level materials. WTP and reservoirs are of good quality concrete structures. The transmission pipelines are made of HDPE material which has 60 years of life-span and can withstand moderate weather conditions.

[6] The community volunteers are maintaining the assets at the moment and the condition of assets is good.

[7] The assets are under the control of community agencies and have adequate funds to enhance the assets that are/will affected by climate change events.

[8] Advanced technical capabilities are readily available within the community to design more sustainable assets with climate resilient approach.

Asset: Charikot Water Supply System

					extreme weather conditions and cause cracks in the pipelines. ▪ Cracked pipelines lose water during its travel time and trigger higher NRW component and the end-user gets reduced supply of water.		
Increase in intensity of rainfall	on an average intensities will increase by 84%	H	L	M		M	M
Change and shift in events							
Increasing number of extreme rainfall events	events that used to occur every 50 years will now occur every 15 years	H	L	M		M	M

Asset: Tilinchowk Water Transmission Pipeline

Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
	written description of how the threat relates to the asset	*refer to table*			*written explanation of what the impact is, and why it was scored (high, med, low)*	*refer to table*	*refer to table*
Change and shift in regular climate							
Increase in precipitation	On an average intensity of rainfall increases by 1.3.	H[1 2 3 4]	M[5 6 7 8]	H	▪ Under severe storm condition, increased flow would trigger for landslide would damage/in some cases the transmission pipeline may collapse. ▪ Due to the sudden collapse of pipeline along the expected landslide zone, disruption of water supply services can be foreseen to the general public. ▪ Disruption to day to day livelihood. ▪ Disruption to businesses and industries. ▪ Public and others to rely on private water supply	M[9 10]	H

[1] Duration: Long duration of rainfall events with high intensity will occur more frequently that brings more flows to the identified site.
[2] Location: The location of the transmission pipeline at risk is adjacent to a historic landslide location between the cliff and the collection chamber u/s of reservoir.
[3] Intensity: Increase in precipitation frequency and volume would make the location more vulnerable for additional landslides. Precipitation *vs* annual recurrence interval curve shows an increase in precipitation occurs more frequently. More precipitation can be seen in the catchment than that was never experienced before. For example in the past 250mm of precipitation used to occur at every 100 years but in future it can be seen at every 40 years.
[4] Located on South facing slope this means more rain and rainfall runoff can be expected for longer durations.
[5] Materials used in the construction are of HDPE which has moderate weather proof characteristics.
[6] The laying of HDPE transmission line is of no-thought and poor engineering practice.
[7] There is no regular maintenance by the local authorities such as thoughts towards realignment of high risk asset.
[8] There were no protective measures such as buried system with some steel or concrete casing to eliminate the exposed risks.
[9] The local authority is supported by community funds to enhance any water supply assets to provide uninterrupted water supply to the residents of the community.
[10] Advanced technical capabilities are readily available through local consulting firms to design more sustainable assets with climate resilient approach.

Asset: Tilinchowk Water Transmission Pipeline

					arrangement that would cost more money to individuals.		
Increase in intensity of rainfall	on an average intensities will increase by 84%	H	M	H		M	H
Change and shift in events							
Increasing number of landslides	on an average increasing risk of landslides due to climate change will be 84%	H	M	H		M	H

Asset: Kharibot Residential Area Septic Tank System

Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
	written description of how the threat relates to the asset	*refer to table*			*written explanation of what the impact is, and why it was scored (high, med, low)*	*refer to table*	*refer to table*
Change and shift in regular climate							
Increase in intensity of rainfall	On an average intensities will increase by 84%	H[1 2 3 4]	H[5 6 7 8]	H	▪ ST's fail to function efficiently and effectively. ▪ More frequent overflows can be observed due to increased precipitation. ▪ More frequent pollution to the nearest streams. ▪ Public and children will come in contact with the sewage more frequently. ▪ Increases the health risks to the residents.	M[9 10 11]	H

[1] Duration: Long duration of rainfall events with high intensity will occur more frequently.

[2] Location: The residential area is located in the medium - high-intensity rainfall zone.

[3] Intensity: Precipitation *vs* annual recurrence interval curve shows an increase in precipitation occurs more frequently. More precipitation can be seen in the catchment than that was never experienced before. For example in the past 250mm of precipitation used to occur at every 100 years but in future it can be seen at every 40 years.

[4] Located on South facing slope this means more rain and rainfall runoff can be expected for longer durations.

[5] Materials used in the construction of ST's are of conventional stone masonry type. The design and construction of ST's are of poor quality. Due to the poor quality of design and construction, ST's are subjected to frequent leakages.

[6] The existing ST's are not conventional ST's; they are designed to perform as soak-pits.

[7] There is no regular maintenance by the owners of the ST's. In a recent interview with the ST owner revealed that his ST was never desludged in the past 20 years.

[8] There were no protective measures taken to avoid any leakages or overflows from the ST's.

[9] The local authority has Town Development Fund (TDF) to support any better sanitation system that improve the living standards of the residents and minimizes any long-term diseases.

[10] Advanced technical capabilities are readily available through local consulting firms to design more sustainable assets with climate resilient approach.

[11] Community is willing to employ volunteers to operate and maintain any future advanced sewerage system.

Asset: Kharibot Residential Area Septic Tank System

					▪ Increased health care costs and burden on the public health system due to increased visits by sick public. ▪ Decrease in aesthetics. ▪ Decreased life expectancy due to increased morbidity and child mortality. ▪ Increased sick leave and lower work productivity. ▪ Decreased school attendance ▪ Decreased tourism.		
Change and shift in events							
Increasing number of extreme rainfall events	events that used to occur every 50 years will now occur every 15 years	H	L	M		M	M

Asset: Tilinchowk Water Supply System

Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
	written description of how the threat relates to the asset	*refer to table*			*written explanation of what the impact is, and why it was scored (high, med, low)*	*refer to table*	*refer to table*
Change and shift in regular climate							
Increase in flow	An average increase in flow	H[1 2 3 4]	M [5 6 7 8]	H	▪ Under severe flow conditions, the increased flow affects the functionality of the existing reservoirs. ▪ Affects the storage existing capacity due to sediment deposition. ▪ Need more frequent O&M tasks which in turn raise the O&M costs which is a huge burden on the operators and end-user. ▪ The existing distribution system gets clogged during the	M[9 10]	H

[1] Duration: Long duration of rainfall events with high intensity will occur more frequently that brings more flows to the identified site.
[2] Location: The intake and the storage reservoir are located just u/s of the wide catchment basin that could bring flash flows due to increased high-intensity rainfall.
[3] Intensity: Increase in precipitation frequency and volume would make the location more vulnerable for flash flows that would trigger shock-loads at the reservoir. Precipitation *vs* annual recurrence interval curve shows an increase in precipitation occurs more frequently. More precipitation can be seen in the catchment than that was never experienced before. For example in the past 250mm of precipitation used to occur at every 100 years but in future it can be seen at every 40 years.
[4] Located on South facing slope this means more rain and flash flows can be expected for longer durations.
[5] Materials used in the construction of intake, reservoirs, transmission and distribution lines are of above adequate level.
[6] The design and construction of reservoir and distribution system are adequate and safe. However, there is no WTP in between the intake and the storage reservoir.
[7] Regular maintenance at the reservoir is performed by the authorities.
[8] There were no protective measures taken for transmission lines, reservoir and the distribution system such as buried system with some steel or concrete casing to eliminate the exposed risks.
[9] The local authority is supported by community funds to enhance any water supply assets to provide uninterrupted water supply to the residents of the community.
[10] Advanced technical capabilities are readily available through local consulting firms to design more sustainable assets with climate resilient approach.

Asset: Tilinchowk Water Supply System

					off-peak time and needs more attention to unclog the sediments for effective and efficient operation of the system. ▪ Since there is no WTP between the source and the reservoir, the heavily sedimented water will reach the consumers which would have huge impact on the public health.		
Increase in intensity of rainfall	on an average intensities will increase by 84%	H	M	H		M	H
Change and shift in events							
Increasing number of storms	On an average the events that used to occur every 50 years will now occur every 15 years	H	M	H		M	H